

National Aeronautics and
Space Administration



ARSET

Applied Remote Sensing Training

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Satellite Imagery Access, Interpretation, and Tools for Dust, Smoke, and Pollution Monitoring

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Satellite Remote Sensing of Air Quality: Data, Tools, and Applications

Tuesday, May 23, 2017 – Friday, May 26, 2017

Indian Institute of Tropical Meteorology, Pune, India

Learning Objectives

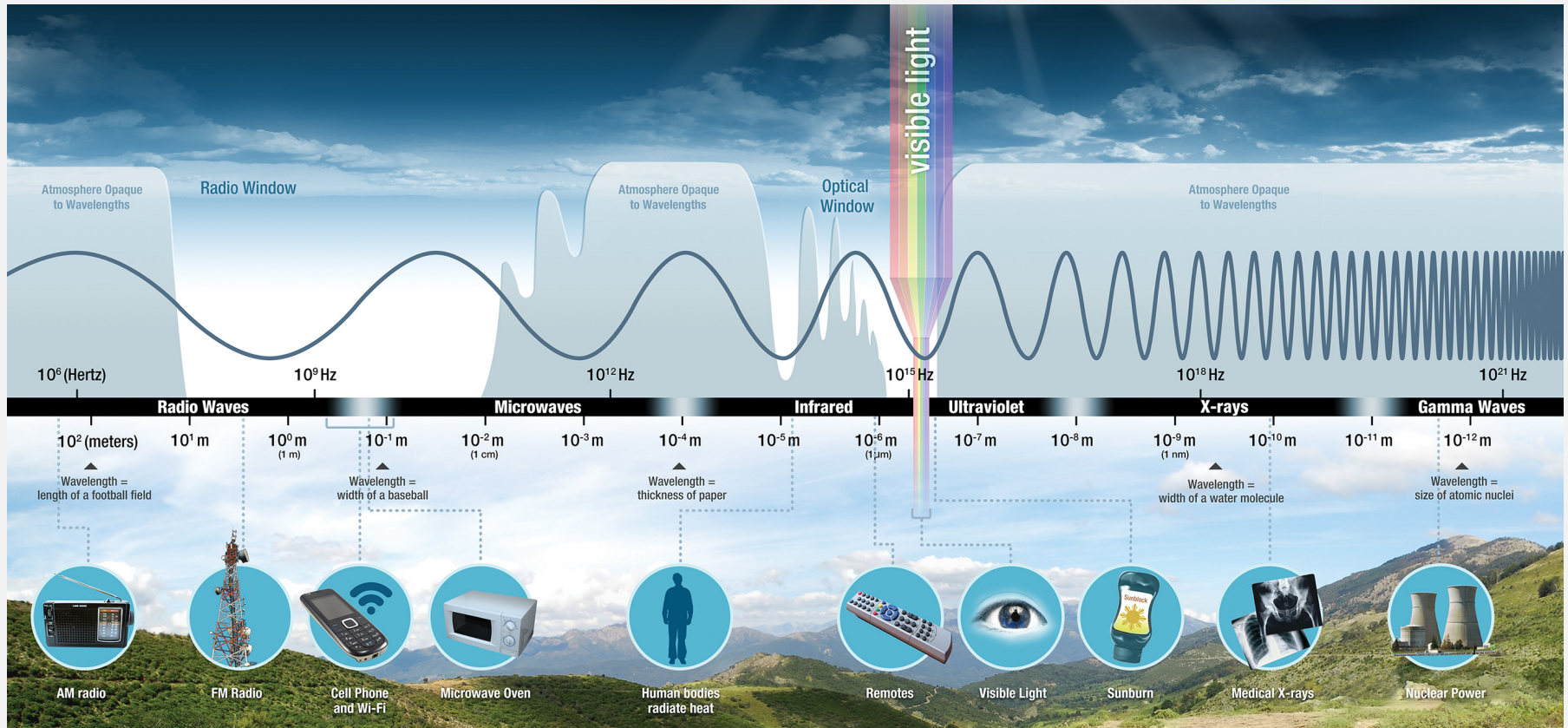
By the end of this presentation, you will be able to:

- recognize satellite imagery, label features, and recite applications of satellite imagery
- access and perform basic analysis of satellite imagery

Visible Image Science

- Visible satellite images are essentially photographs
- All the energy collected by the visible sensors (cameras) onboard the satellite is light energy from the sun, reflected by the Earth
- The reflectance is a measure of albedo, which is the percentage of light energy reflected by the Earth
- The higher the albedo, the more light reflected back into space (i.e. cloud appears bright)
- The lower the albedo, the more light energy is absorbed (i.e. water appears dark)

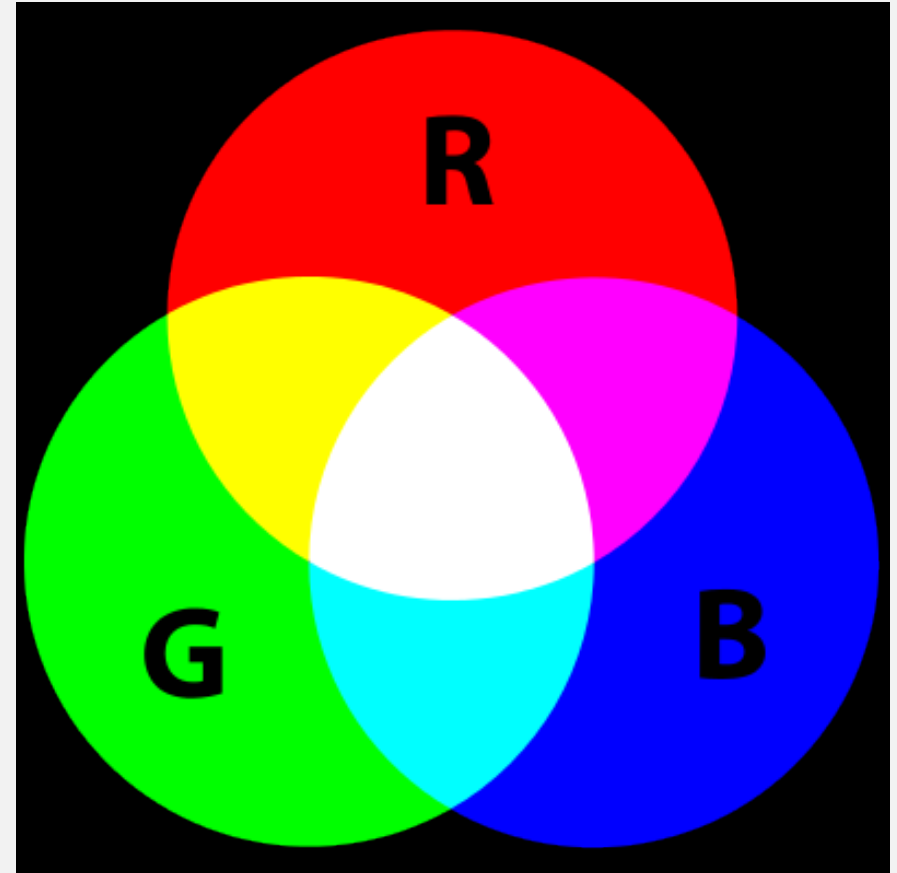
Wavelength Selection



Earth observing satellite remote sensing instruments typically make observations at many discrete wavelengths, or **wavelength bands**

RGB Imagery

- Create an image using any 3 bands
- Load red, green, and blue satellite bands into corresponding display channels
- Simulates what the human eye sees



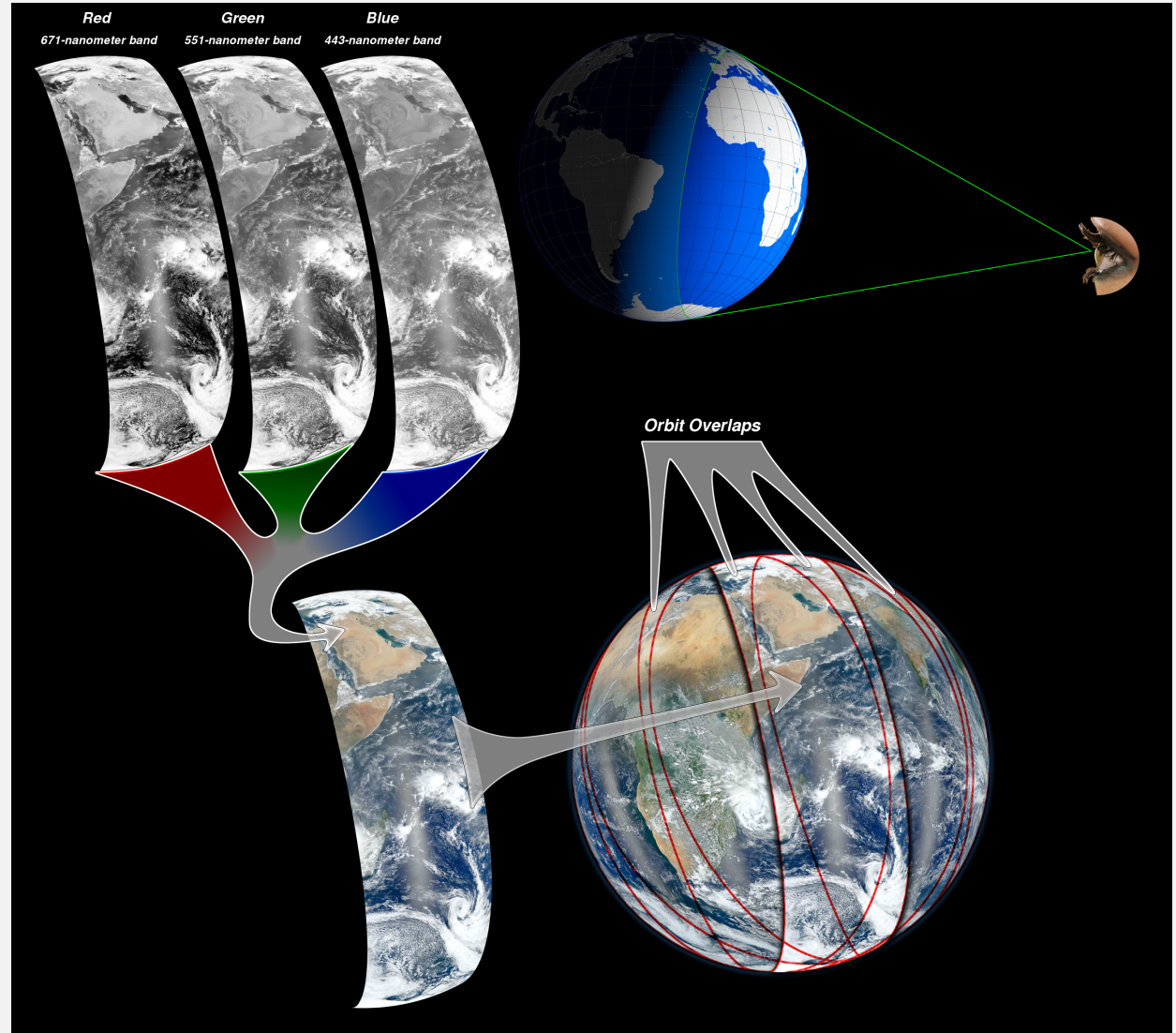
True Color Image (or RGB)

A MODIS “true color image” will use MODIS visible wavelength bands 1, 4, 3

R = 0.66 μm

G = 0.55 μm

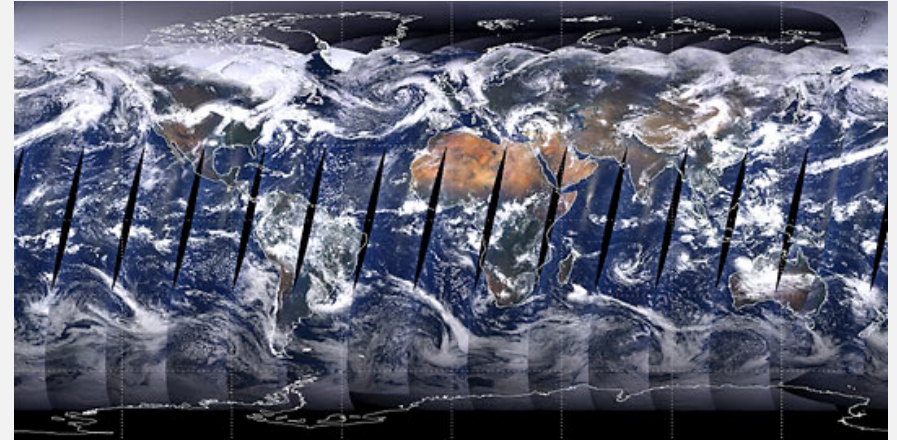
B = 0.47 μm



Moderate Resolution Imaging Spectroradiometer

MODIS

- Spatial Resolution
 - 250 m, 500 m, 1 km
- Platform
 - Terra & Aqua
- Temporal Resolution
 - 2000 – present
 - Daily, 8-day, 16-day, monthly, quarterly, yearly
- Data Format
 - Hierarchical Data Format – Earth Observing System (HDF-EOS)

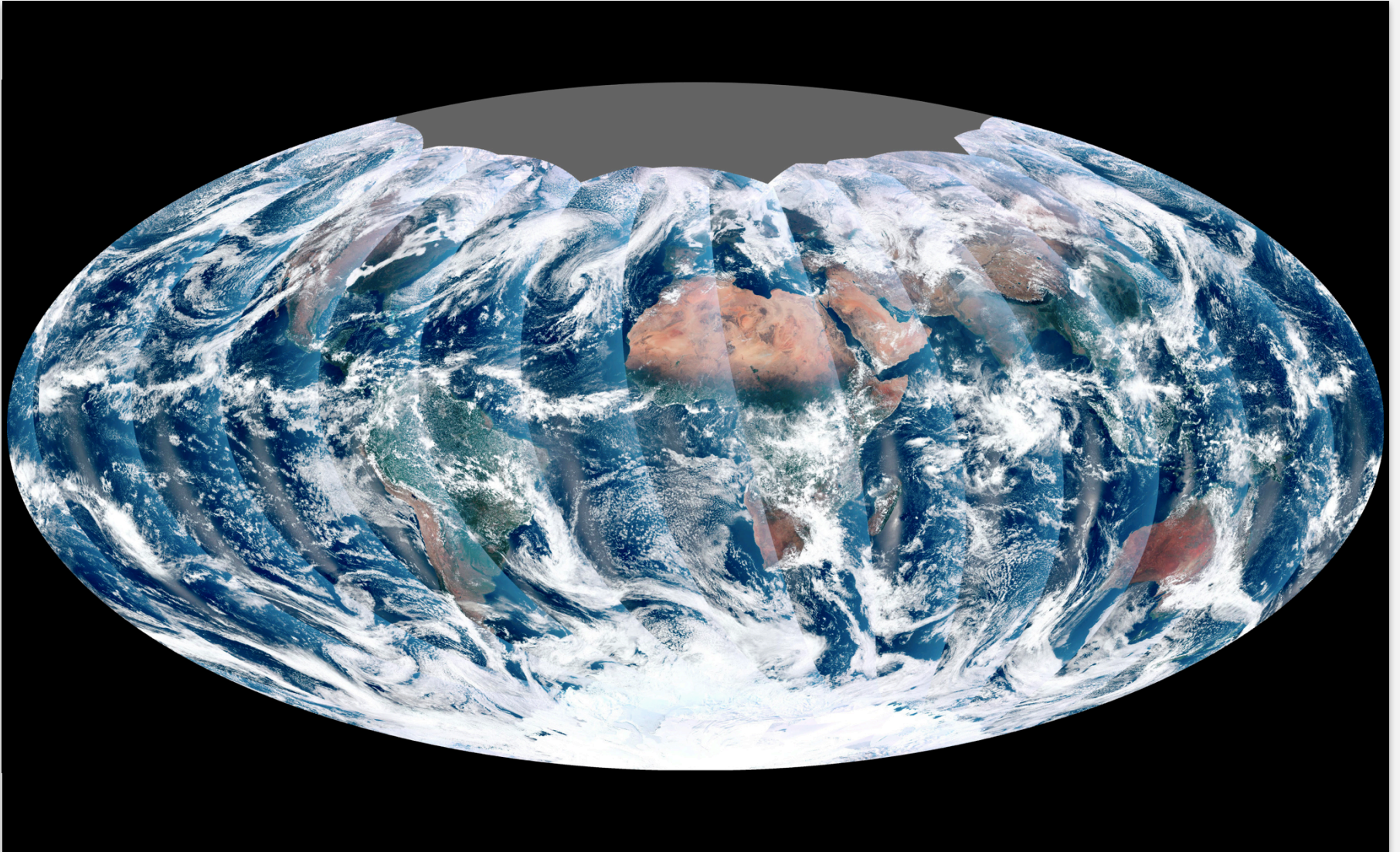


- Spectral Coverage
 - 36 bands (major bands include red, blue, IR, NIR, MIR)
 - Bands 1-2: 250 m
 - Bands 3-7: 500 m
 - Bands 8-36: 1,000 m

MODIS Reflected Solar Bands

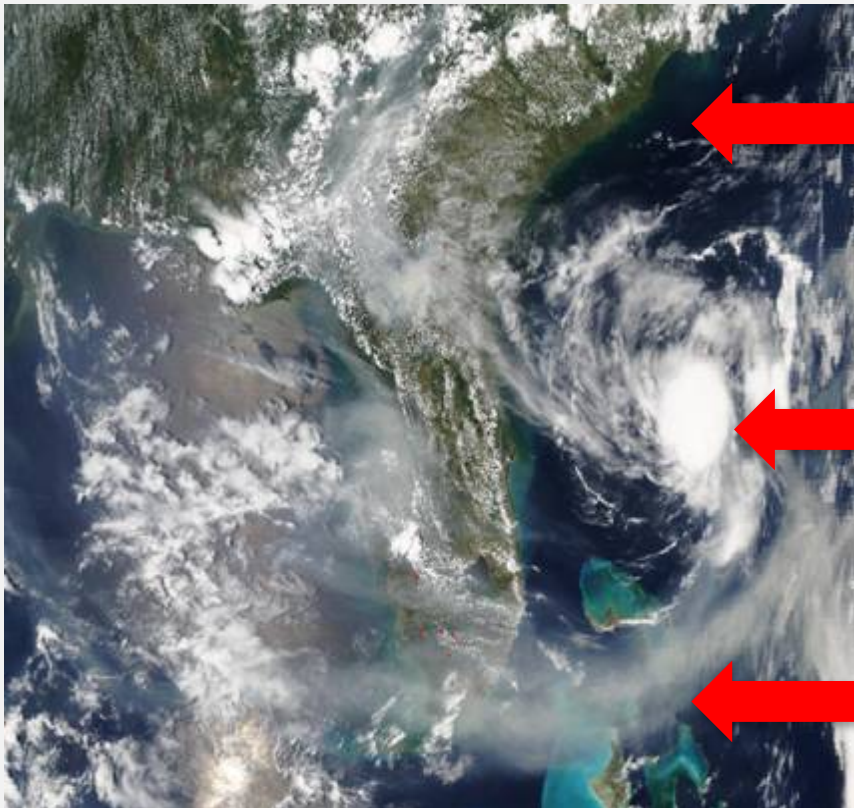
	Primary Use	Band No.	Bandwidth (nm)	* 500m Spatial Resolution ** 250m Spatial Resolution
250 m	Land/Cloud Boundaries	1**	620-670	
		2**	841-876	
500 m	Land/Cloud Properties	3*	459-479	
		4*	545-565	
		5*	1230-1250	
		6*	1628-1652	
		7*	2105-2155	
	Ocean Color/ Phytoplankton/ Biogeochemistry	8	405-420	
		9	438-448	
		10	483-493	
		11	526-536	
		12	546-556	
		13	662-672	
		14	673-683	
		15	743-753	
		16	862-877	
	Atmospheric Water Vapor	17	890-920	
		18	931-941	
		19	915-965	

VIIRS Image



Doing More with Satellite Imagery

If we understand the physics of how particular wavelengths interact with objects we can create images to emphasize what we want to see

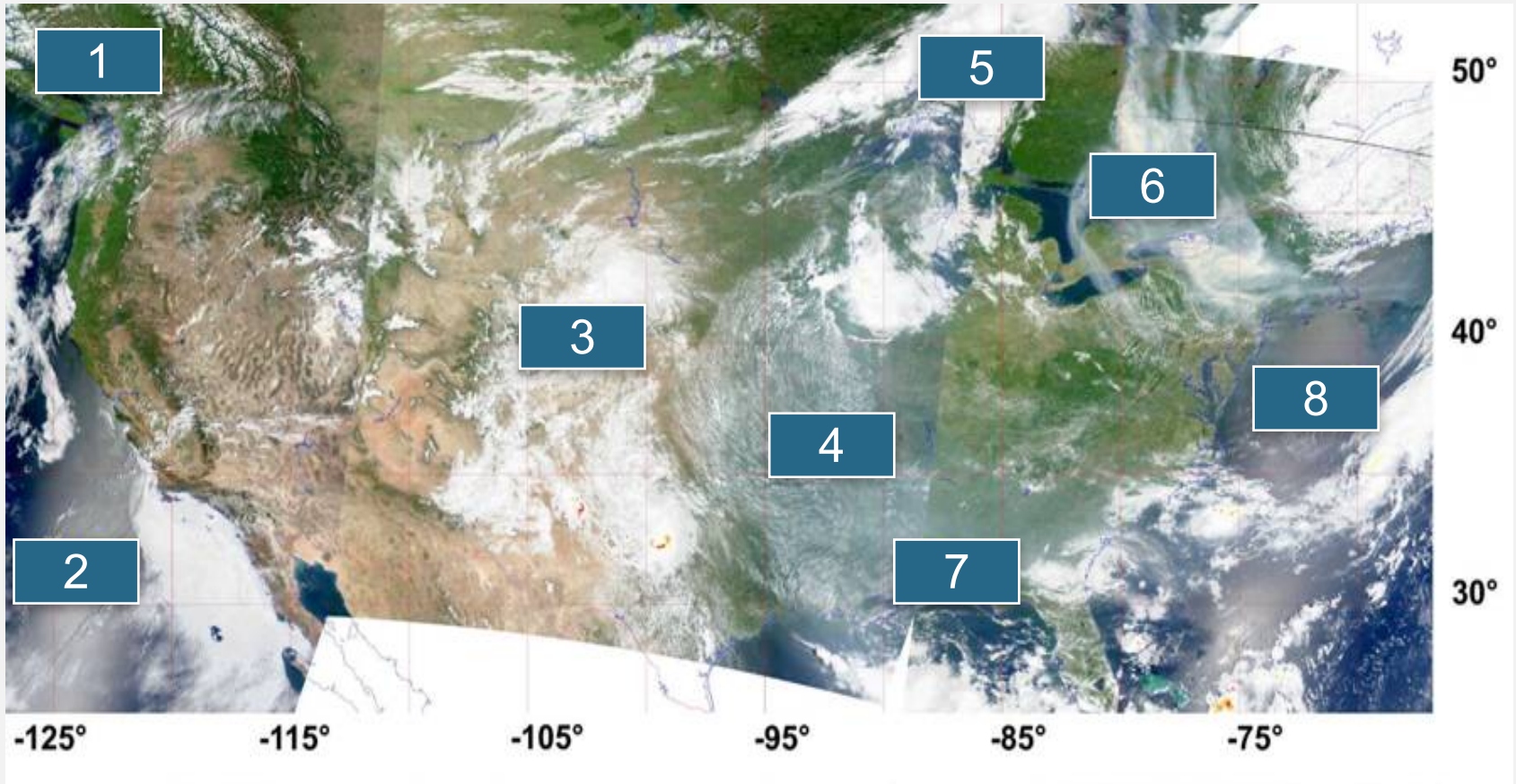


Visible imagery water is dark because it absorbs most of the energy

Clouds are white because they reflect most incoming energy

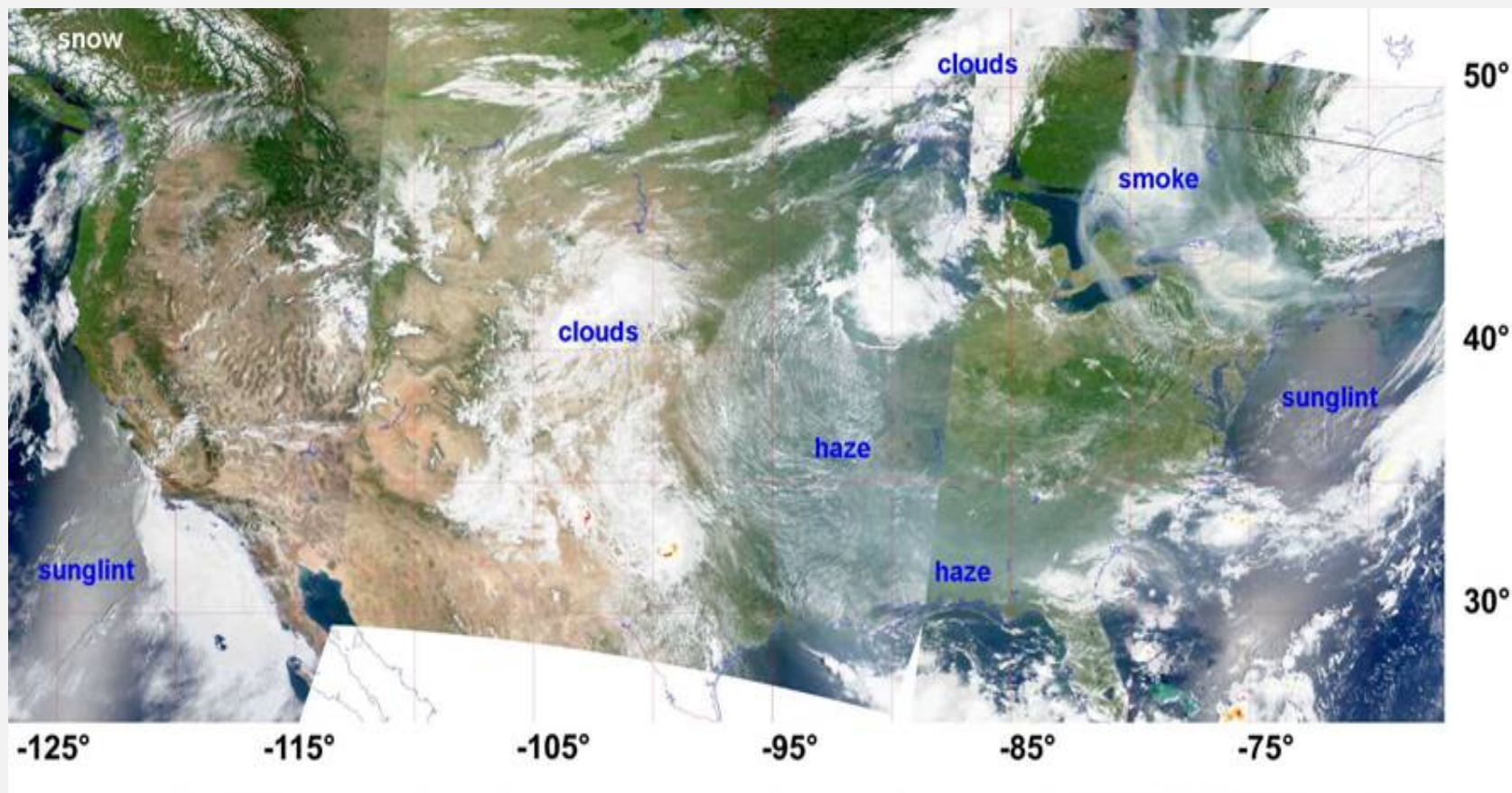
Pollution is hazy depending on its absorption properties

What can we learn from true color imagery?



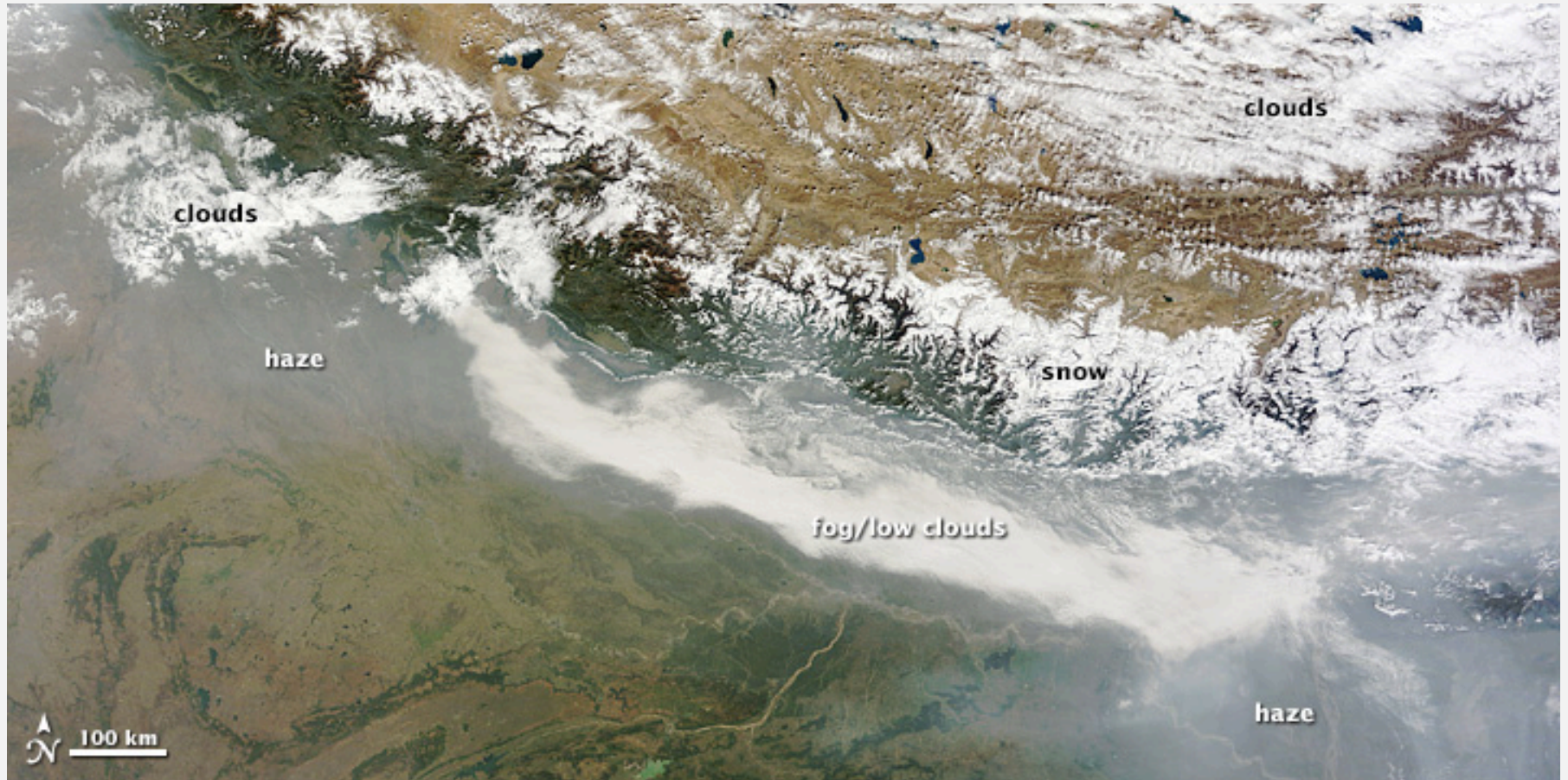
(Possible) identification of land, ocean, and atmosphere features

What can we learn from true color imagery?

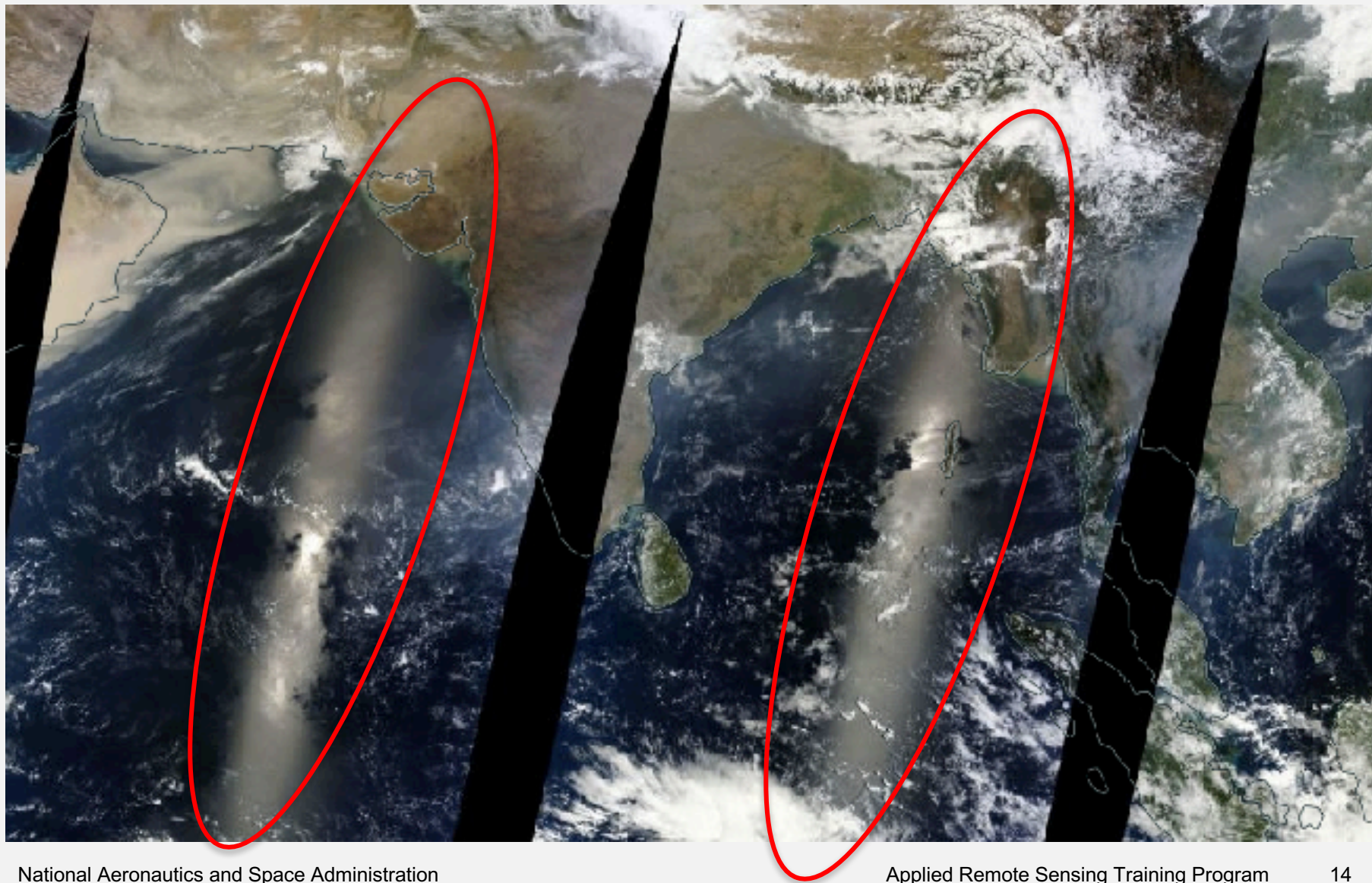


(Possible) identification of land, ocean, and atmosphere features

Features in True Color (Atmosphere)

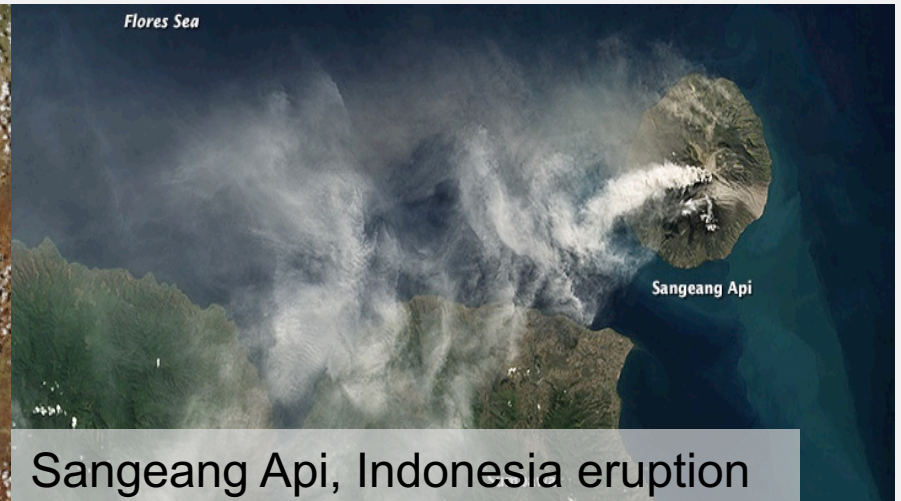
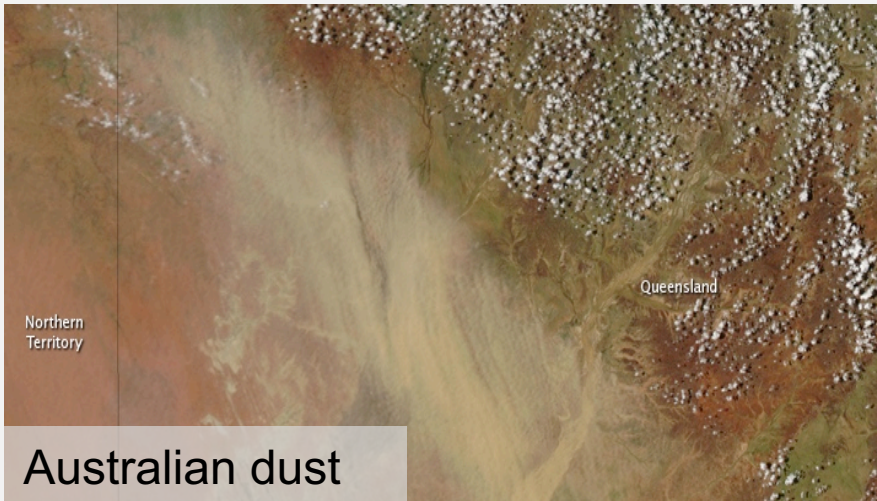


Glint



Feature Identification

More reliable when a clear source is in the image



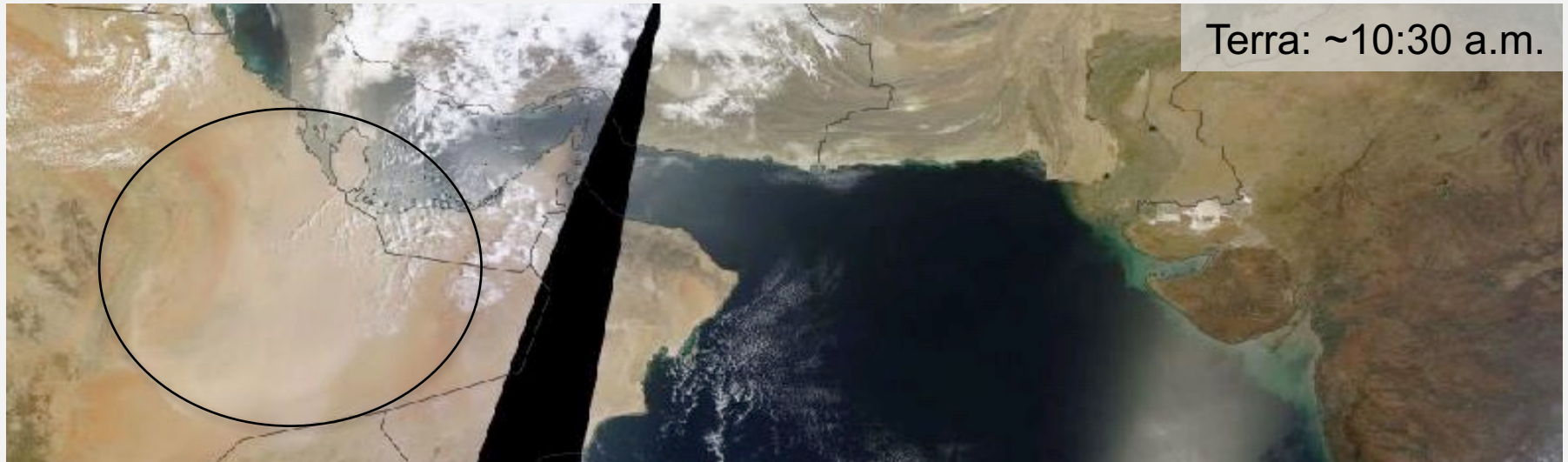
Feature Identification

More reliable when a clear source is in the image



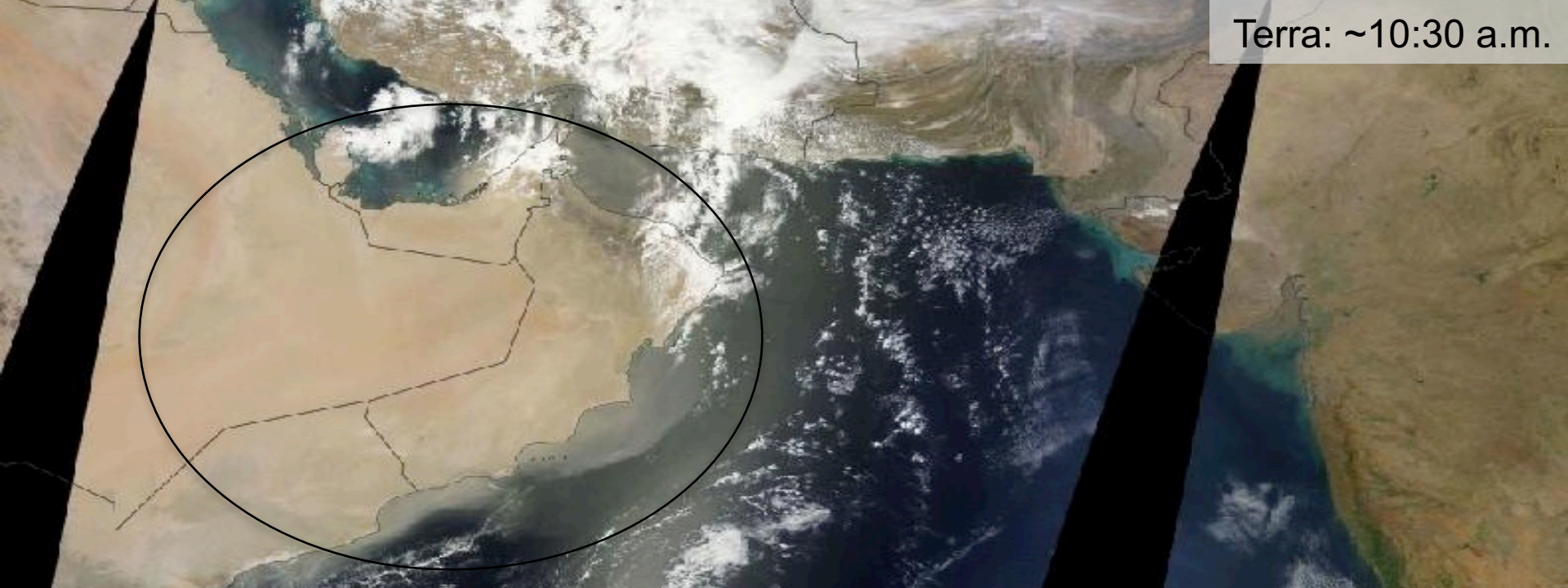
Using Time Series Imagery

Dust Transport

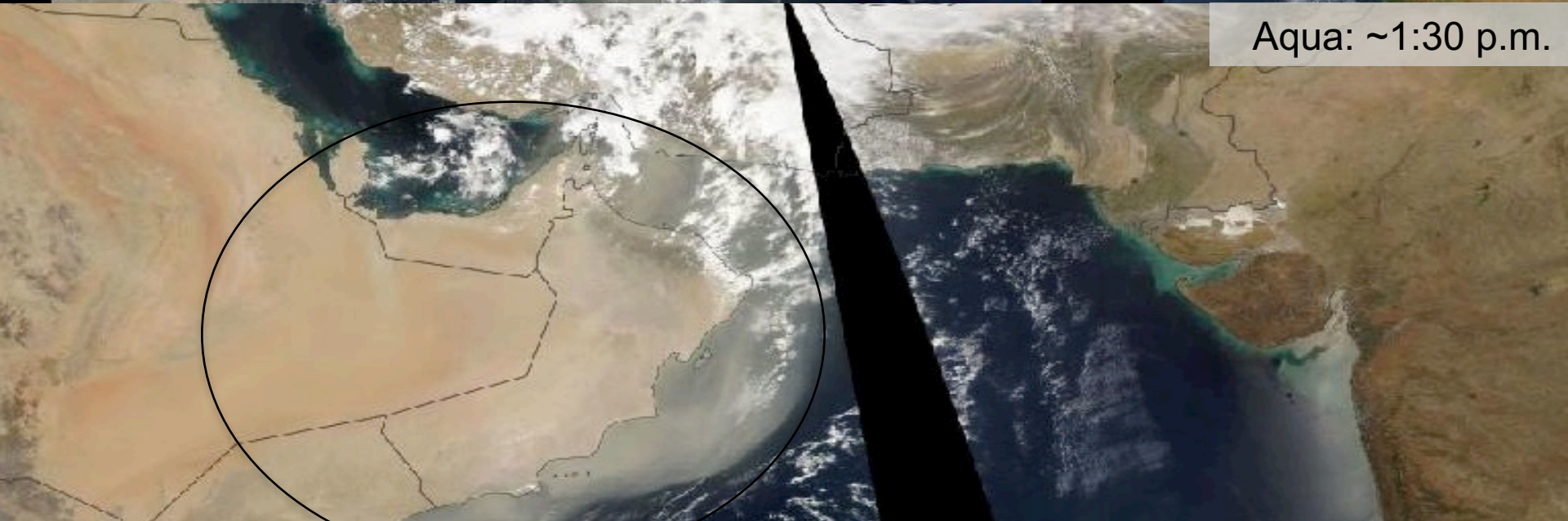


April 6, 2013; Images from NASA Worldview

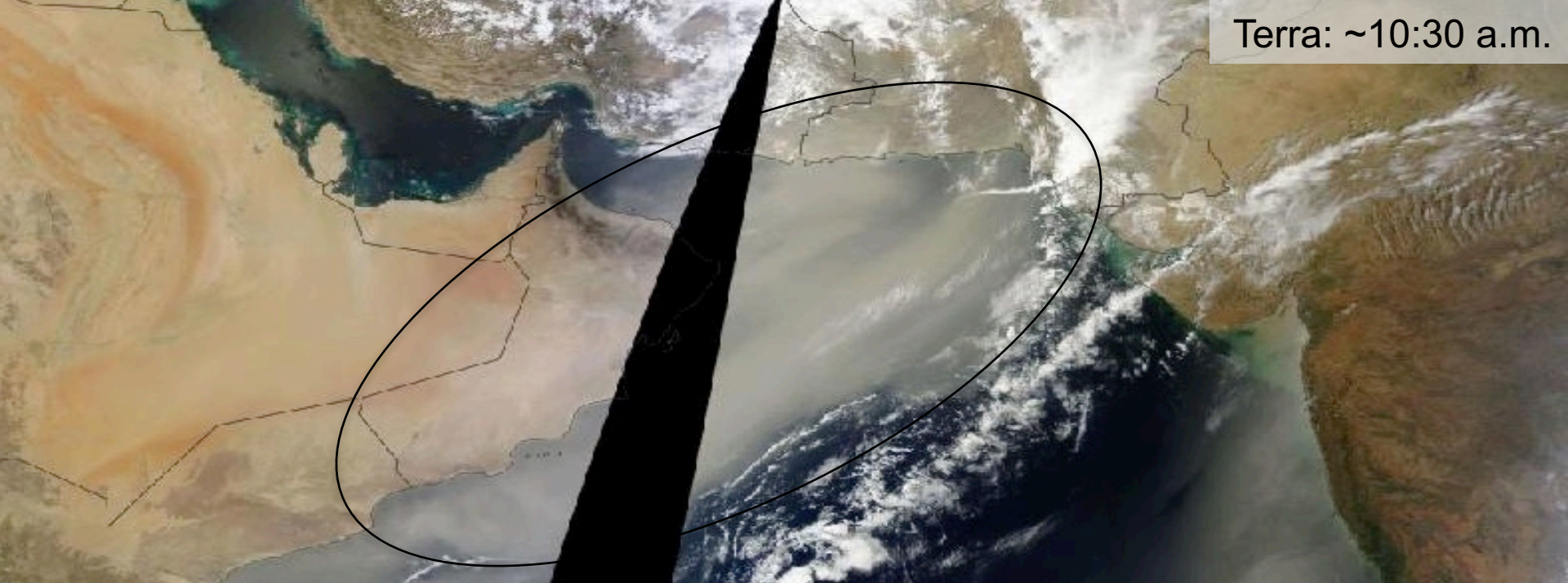
Terra: ~10:30 a.m.



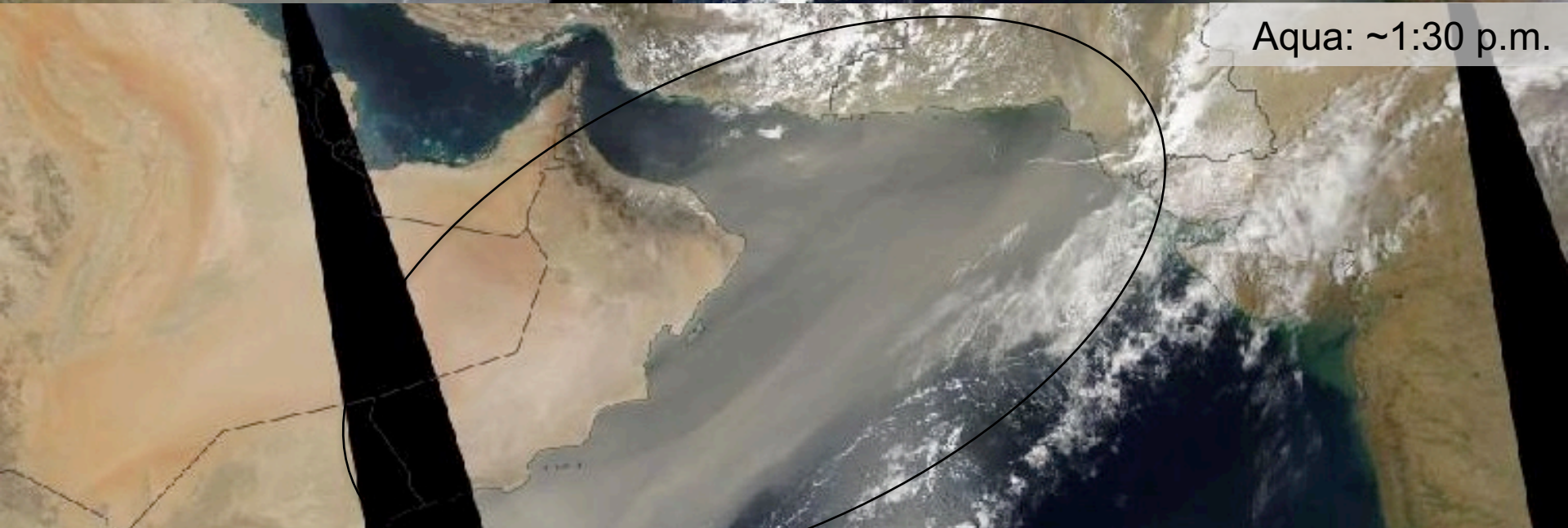
Aqua: ~1:30 p.m.



April 7, 2013; Images from NASA Worldview



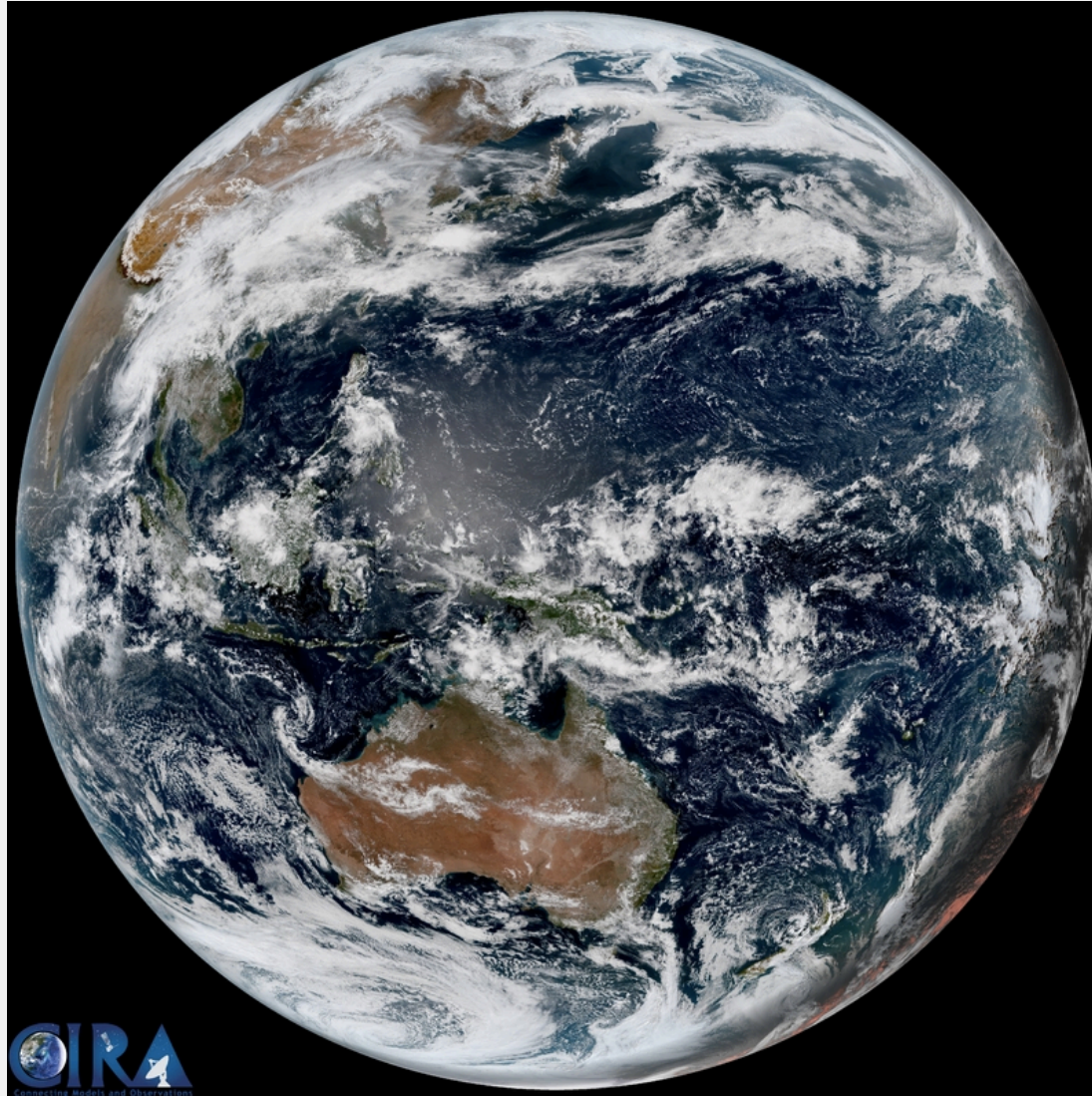
Terra: ~10:30 a.m.



Aqua: ~1:30 p.m.

April 8, 2013; Images from NASA Worldview

Geostationary Observations



GOES-16 Loop: Smoke Over the Southeast U.S.

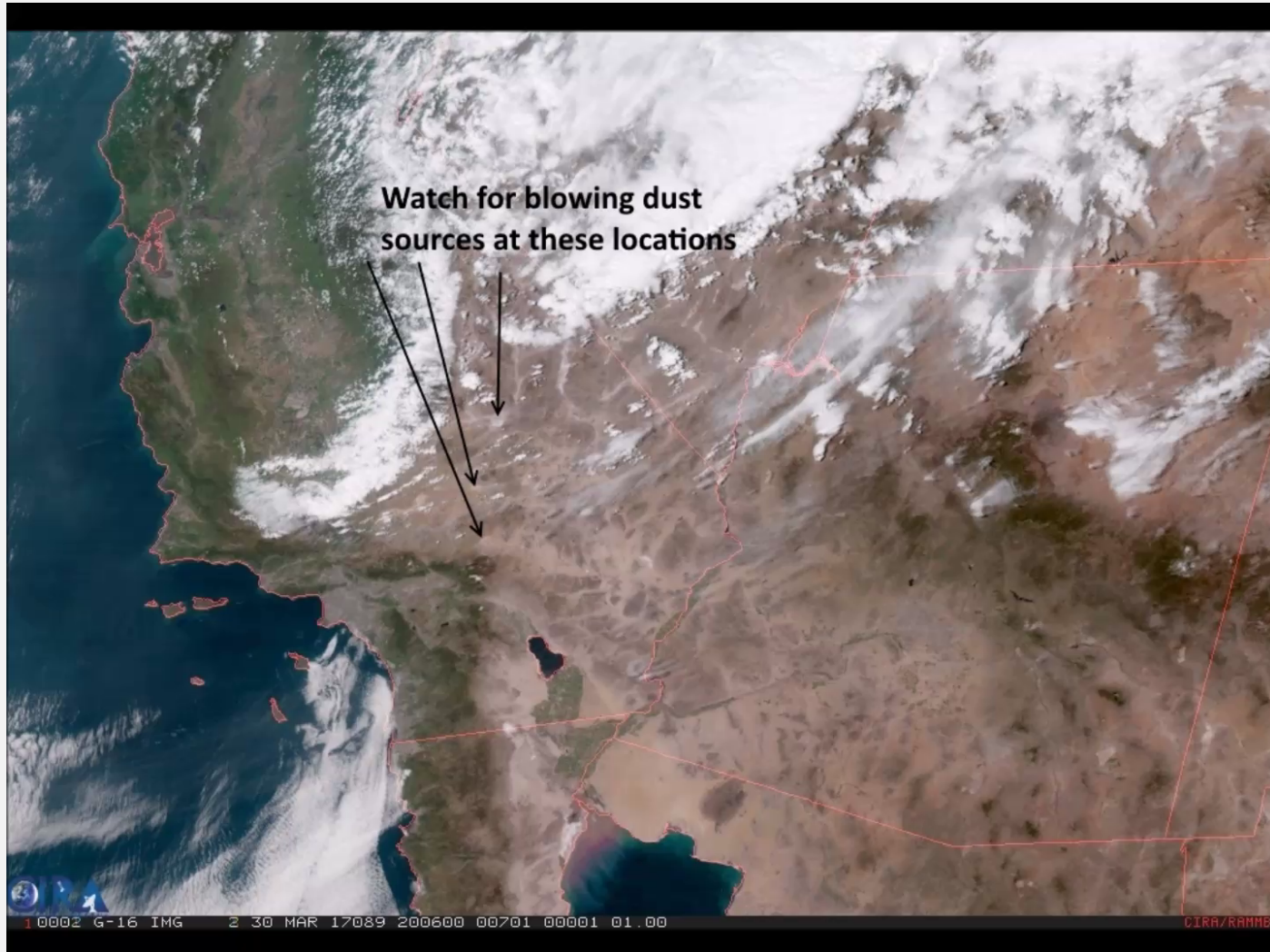


Image: NOAA CoRP, STAR: http://rammb.cira.colostate.edu/ramsdiss/online/loop_of_the_day/

HIMAWARI-8 Loop: Fog and Smog over India

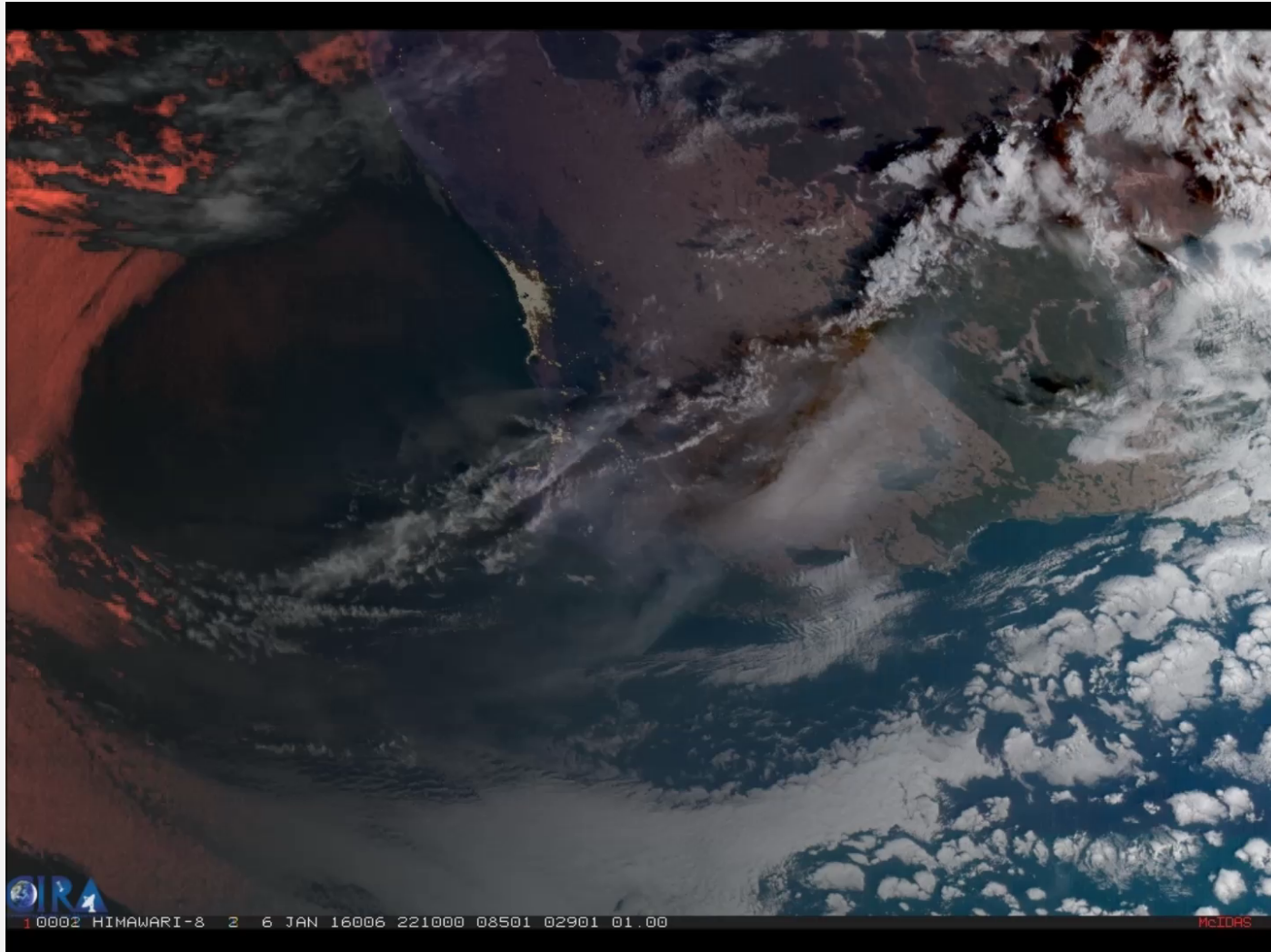


Image: NOAA CoRP, STAR: http://rammb.cira.colostate.edu/ramsdisk/online/loop_of_the_day/

GOES-16 Loop: Smoke Over the Southeast U.S.

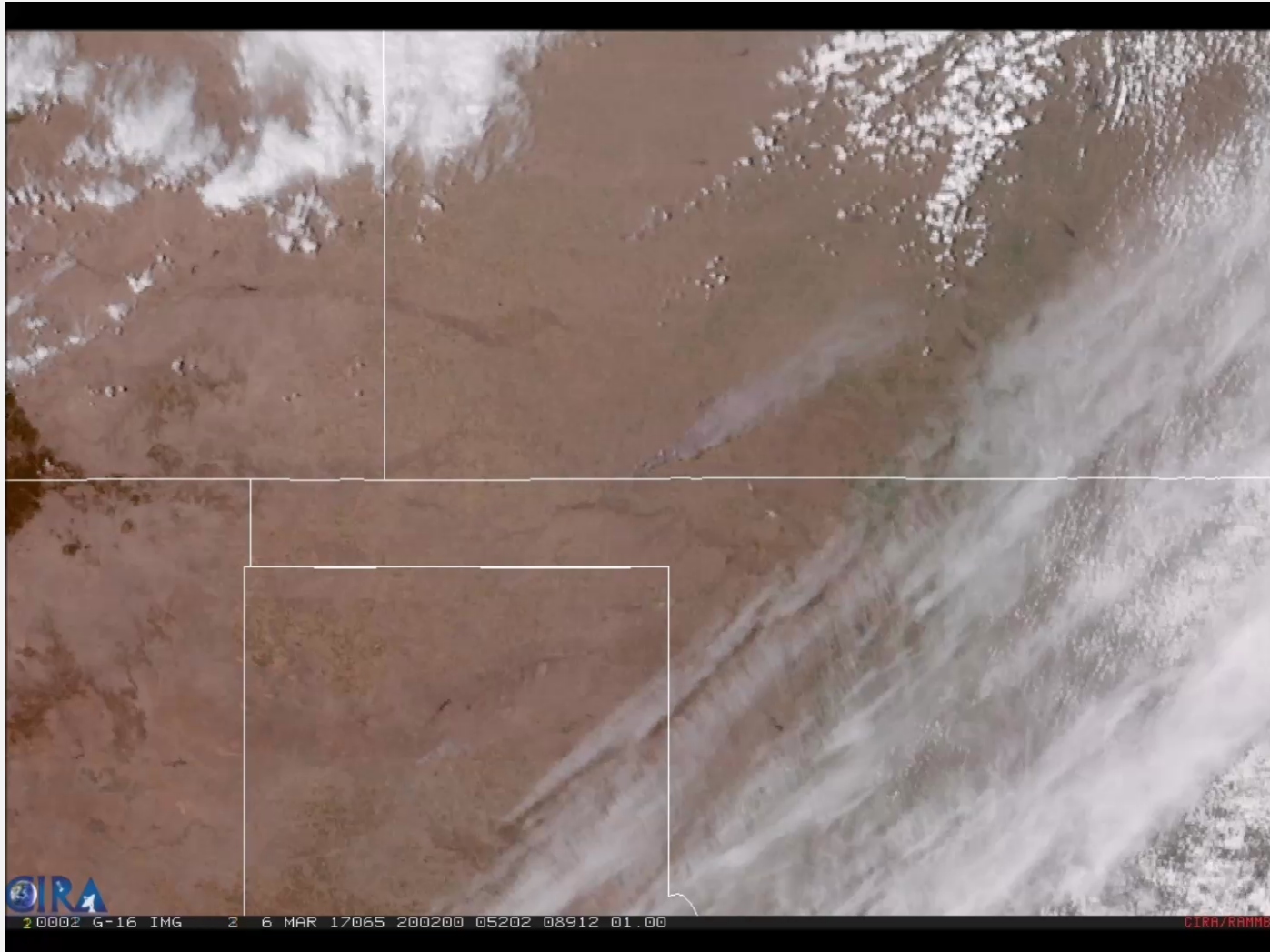


Image: NOAA CoRP, STAR: http://rammb.cira.colostate.edu/ramsdisk/online/loop_of_the_day/

HIMAWARI-8 Loop: Fog and Smog over India

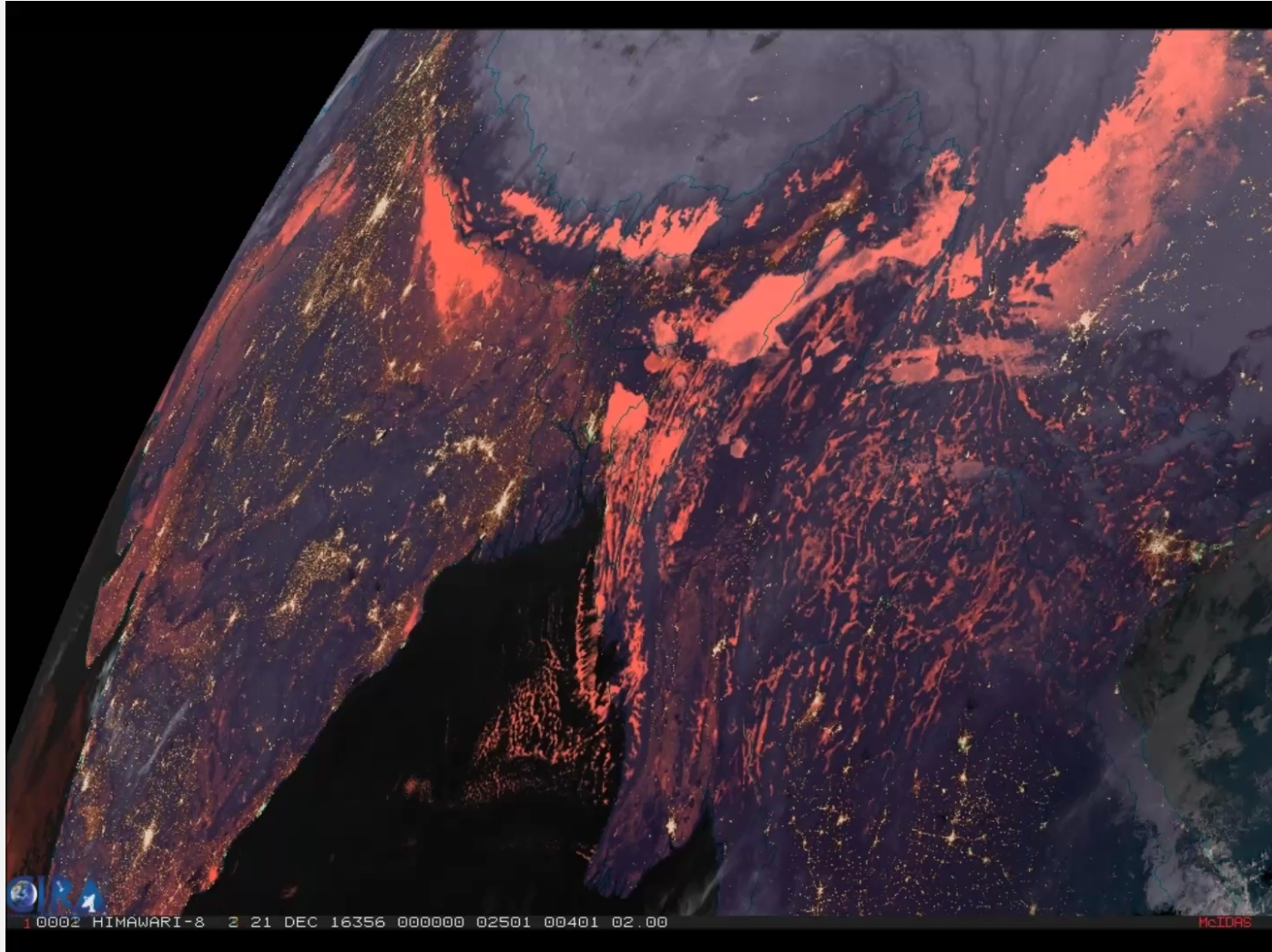


Image: NOAA CoRP, STAR: http://rammb.cira.colostate.edu/ramsdisk/online/loop_of_the_day/

HIMAWARI-8 Loop: Fog and Smog over India

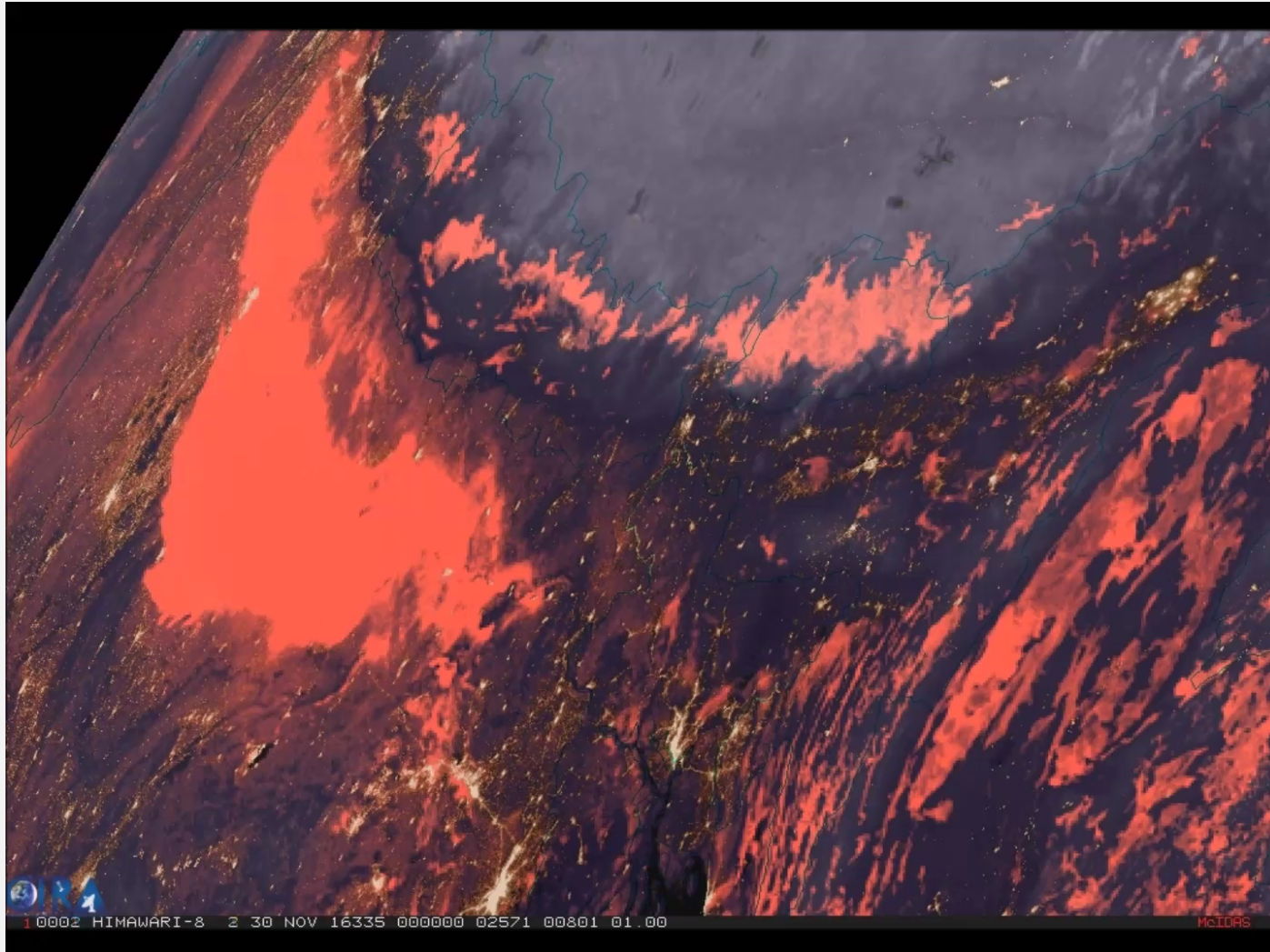


Image: NOAA CoRP, STAR: http://rammb.cira.colostate.edu/ramsdisk/online/loop_of_the_day/

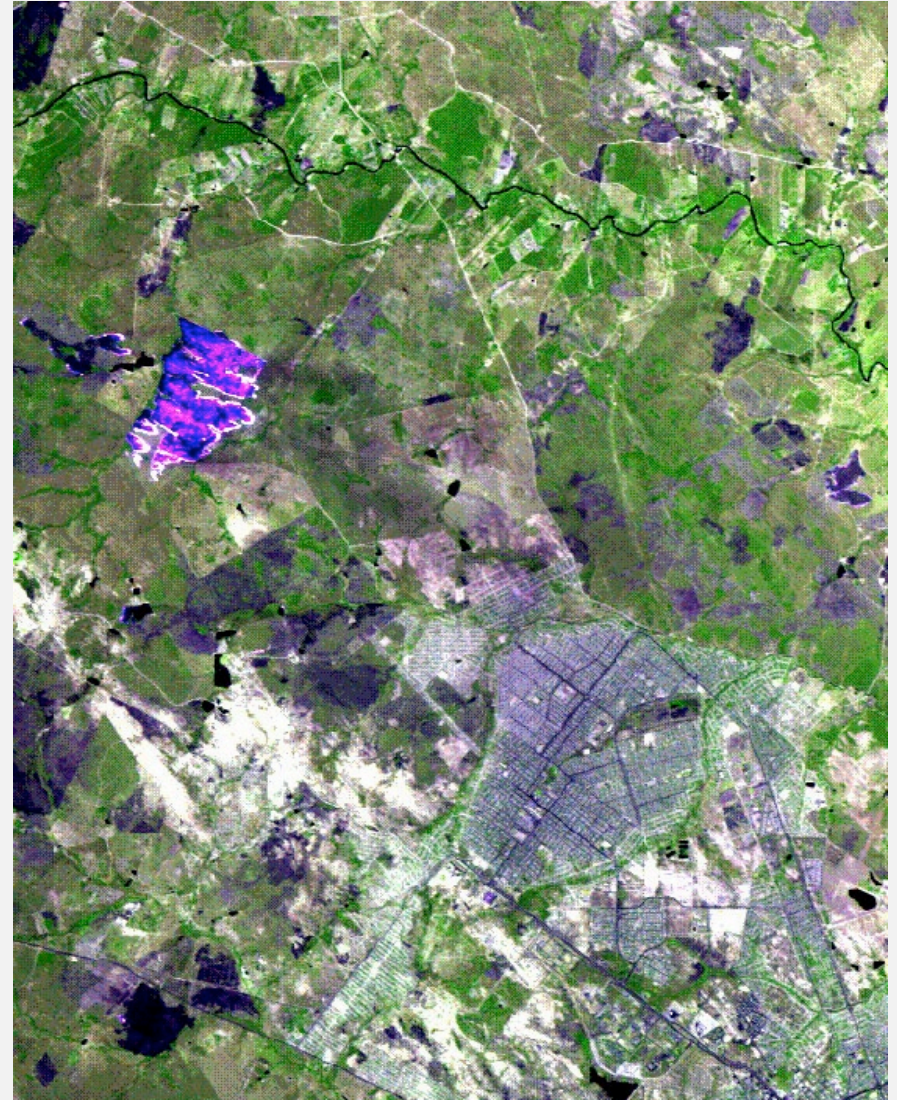
False Color Images

- Load bands into the red, green, and blue display channels
- Do not correspond to the visible red, green, and blue wavelengths

R = 1.6 μm

G = 1.2 μm

B = 2.1 μm



True vs. False Color Images



R = 0.66 μm

G = 0.55 μm

B = 0.47 μm

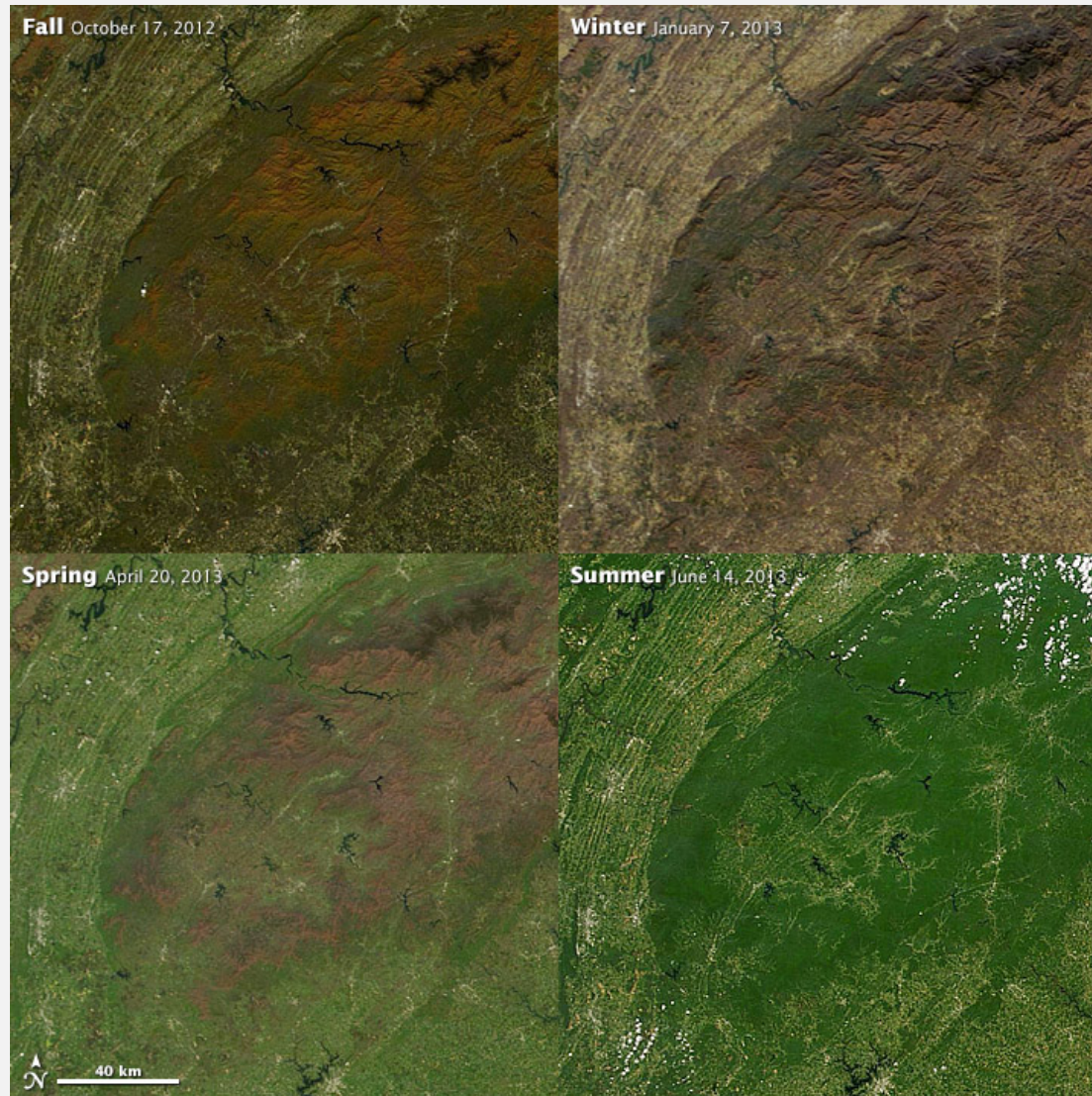


R = 1.6 μm

G = 1.2 μm

B = 2.1 μm

Change in Vegetation Color from Space



Earth Observatory Story

An article on feature detection in an image:

<http://earthobservatory.nasa.gov/Features/ColorImage/page2.php>

Define Colors

The colors in an image will depend on what kind of light the satellite instrument measured. True-color images use visible light—red, green and blue wavelengths—so the colors are similar to what a person would see from space. False-color images incorporate infrared light and may take on unexpected colors. In a true color image, common features appear as follows:



Water

Water absorbs light, so it is usually black or dark blue. Sediment reflects light and colors the water. When suspended sand or mud is dense, the water looks brown. As the sediment disperses, the water's color changes to green and then blue. Shallow waters with sandy bottoms can lead to a similar effect.

Sunlight reflecting off the surface of the water makes the water look gray, silver, or white. This phenomenon, known as sunglint, can highlight wave features or oil slicks, but it also masks the presence of sediment or phytoplankton.

Sediment colors the sea near the mouth of the Zambezi River. The water grows darker offshore as the sediment disperses. (NASA Earth Observatory images by Robert Simmon, using Landsat 8 data from the USGS Earth Explorer.)

Image Archive and Gallery Links

- ARSET Satellite Imagery Overview and links
 - <http://airquality.gsfc.nasa.gov/index.php?section=64>
- MODIS Rapid Response Site
 - <http://earthdata.nasa.gov/data/near-real-time-data/rapid-response>
- NASA's Visible Earth
 - <http://visibleearth.nasa.gov>
- NASA's Earth Observatory
 - <http://earthobservatory.nasa.gov>
- NASA's Earth Observations (NEO)
 - <http://neo.sci.gsfc.nasa.gov>
- MODIS-Atmos (MODIS Atmosphere Product Reference Site)
 - <http://modis-atmos.gsfc.nasa.gov/IMAGES/index.html>
- GLIDER Tool
 - <http://www.ssec.wisc.edu/hydra>

Tour of Some Useful Image Archives

- Earth Observatory: Events & More
 - <http://earthobservatory.nasa.gov>
- Worldview: Near Real-Time
 - <http://earthdata.nasa.gov/labs/worldview>

Questions & Discussion Prompts

- What are the difference between true color and false color images?
- What are three applications of true color images for air quality monitoring?
- Does access of near real-time, true color imagery provide any useful information to air quality forecasters?



Questions
